Effects of infrasound on man (invited)

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EFFECTS OF INFRASOUND ON MAN

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INTRODUCTION

It has often been claimed that infrasound may influence the human cardiovascular system, affect task performance and cause a number of nuisances like dizziness, nausea and headache. Most observations of this kind are from human everyday environment, where both exposures and observations are uncertain. Therefore laboratory experiments are needed where the exposure is well known (infrasound without vibrations, audio frequency sound etc.), and where a number of well defined parameters are recorded. Experiments like these have been carried out but the results are not very concordant, and further investigation is needed.

This investigation deals with both physiological parameters, task performance and subjective nuisances. However, the results from the task performance measurements have already been published [1] and will not be included in this paper.

EXPOSURE

The experiments were carried out in a 16 m^3 infrasound test chamber equipped with a ventilating system. The infrasound was generated by 16 large electrodynamic loudspeakers. Four different exposures were used. In addition to two infrasound signals, a quiet exposure was used, and for comparative reasons, an audio frequency noise.

A - quiet
B - traffic noise at a level of Leq = 71 dB(A)
C - low level infrasound, see figure 1. Total SPL= 100 dB
D - high level infrasound, see figure 1. Total SPL= 120 dB

C and D were broadband infrasound signals, frequency shaped along the threshold curve 5-25 Hz, thus making the "low" and "high" frequencies equally audible. The total spectrum C is hardly audible, while D is subjectively loud.

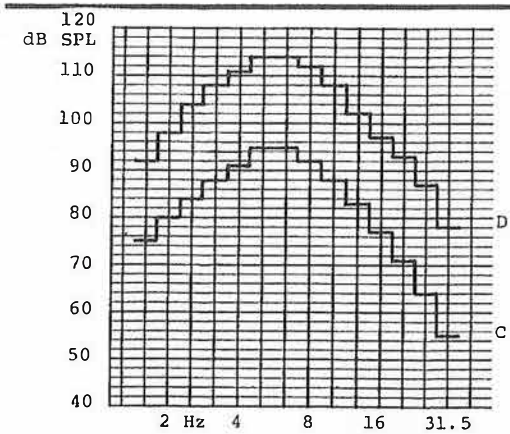

Figure 1.
1/3 octave analysis of the stimuli C and D.

Total SPL:
C: 100 dB
D: 120 dB

RECORDINGS

Systolic and diastolic blood pressure were measured every hour during the exposures, and at fixed times ECG recordings were made. Before and after each exposure audiograms were taken. After each exposure a questionnaire was filled out in order to register subjective impressions during the exposure.

EXPERIMENTAL DESIGN

15 youngs students and one person of 43 years were used as subjects, half of each sex. They all participated in the experiments four days, each day for 4 hours. In a 4-hour setting 3 hours were used for exposure to one of the four conditions given above. The subjects participated two at a time and they were all exposed to all four conditions, although not in the same order. A latin square design was used to balance out learning effects. Except for small pauses, the subjects worked with the task performance tests all the time.

RESULTS

The results from the blood pressure measurements can be seen in table I a). A 3-way analysis of variance has been carried out having the independent variables 1) person, 2) sound exposure and 3) experiment number for that particular person. No significant effects of the sound exposure were seen for neither systolic nor diastolic blood pressure.

The ECG recordings have not been analysed yet.

From the audiograms a variable SHL was derived as the sum of hearing loss at the 7 octave frequencies 125 Hz - 8 kHz. The influence on hearing on an experiment was calculated as Δ SHL = SHL (after exposure) - SHL (before exposure). In table I b) Δ SHL is shown as a function of sound exposure. The 3-way analysis of variance indicates a main effect from the sound exposure (significant at 0.6% level) and it is quite obvious that Δ SHL is greater for B than for the other exposures.

From the table it can be seen that the values of Δ SHL in case A, C and D are negative. This means that the hearing of the subjects became better during the experiments, except when exposed to traffic noise. An explanation may be, that the subjects had a minor temporary threshold shift (TTS) when they arrived for the experiments.

The value of Δ SHL in case B is approximately 30 dB higher than in the other cases, indicating that the traffic noise (Leq = 71 dB (A)) introduced a TTS. A detailed analysis has shown that the TTS was broadband and the total value of 30 dB thus leaves about 4 dB for each of the 7 frequencies.

The questionnaire used to obtain recordings of subjective impressions presented 7 questions each followed by a horizontal line. The ends of the line were given possible but extreme answers to the question, and answers were given with a cross on the line exactly at the place where the subject felt that this answer could be represented. All positions were allowed. Results are given in table I c). Figures are given in percent of the "answering line" and the answers given at the ends of the line and thus corresponding to 0 and 100% are also mentioned.

	Sound exposure				level of
	A	B	C	D	significance
a)					
Systolic blood pressure (mm Hg)	120.4	119,4	120.3	120.5	-
Diastolic blood pressure (mm Hg)	77.6	77.8	75.7	75.8	-
b)					
Δ SHL (dB)	-19.5	11.7	-18.9	-14.3	0.006
c)					
1. Have you felt dizziness? (not at all - a lot)	9	21	8	12	0.048
2. Have the tests been titing? (not tiring - very tiring)	50	55	52	58	-
3. Have you felt nausea? (a lot - not at all)	83	90	85	88	-
4. Have you been annoyed by noise or rumble? (not annoyed - very annoyed)	10	82	11	70	<0.001
5. Have you had a headache? (not at all - severe)	11	34	12	13	<0.001
6. How have you felt? (dull - fit)	46	42	40	29	-
7. Have you felt pressure on your ears? (a lot - not at all)	88	83	93	51	<0.001

Table I. Obtained results from a) blood pressure measurements, b) audiometrical measurements and c) questionnaires. Indicated values are mean values for the sound exposure. The level of significance refers to main effects of sound exposure in a 3-way analysis of variance.

The answers from three questions show highly significant differences between exposures. Answers to question 4 clearly shows that traffic noise (B) and high level infrasound (D) are really annoying.

Values in A and C are almost the same, however not equal to zero, probably because of noise from other activities in the building, the ventilating system and the electronic equipment.

Question 5 dealth with headache and it can be seen from the table that the "headache percent" is 34 in case B, while only 11-13 in A, C and D. This clearly indicates that traffic noise introduced headache, while infrasound did not.

The feeling of pressure on the ear given by the high level infrasound is very obvious as can be seen from answers to question 7. However it is not quite certain whether this indicates a real middle ear pressure build-up, or only the hearing of infrasound. A better wording of the question must be considered for future investigations.

Question 1 asked for dizziness and the four sound exposures gave answers that were significantly different at 4.8% level. The "percent of dizziness" was clearly higher in B (21) than in the other cases (8-12). Thus traffic noise introduced a slight dizziness.

In the remaining questions main effects of sound exposure were not significant. In question 2 and 3 figures are nearly the same for all exposures. In question 6 a slightly lower value was obtained in D, indicating a "dull" feeling. However this was not significant.

DISCUSSION

The results seem to indicate, that the most obvious effects of infrasound are the subjective indications related to the hearing of infrasound. In this connection it is interesting to see that the exposure C gave no indications of annoyance, while D - which is only 20 dB above C - gave a very large value of "annoyance". This is probably due to the closeness of the loudness curves in this frequency range. The loudness curves and the connection between loudness and annoyance is the subject of another research project also presented at this conference (by Bjarne Kirk and Henrik Møller).

The infrasound exposures used in this experiment were broadband noise frequency shaped along the hearing threshold curve. This gave a rather small content of "high frequency" infrasound (10-20 Hz). For exemple the 1/3 octave level at 20 Hz was only 93 dB even in the high level case D. For future experiments exposures with pure tones or narrow bands should be used at higher levels.

In the present experimental design each person was exposed to each sound stimulus only once. Therefore only main effects could be found and possible interaction terms - e.g. subjects reacting different to a stimulus - have been ignored. For future experiments the possibility of having at least two exposures to each stimulus should be considered, thus giving the possibility of evaluating the interaction terms.

[1] Henrik Møller: The influence of infrasound on task performance. Conference on Low Frequency Noise and Hearing, 7-9 May 1980 in Aalborg, Denmark, Proceedings edited by Henrik Møller and Per Rubak.